

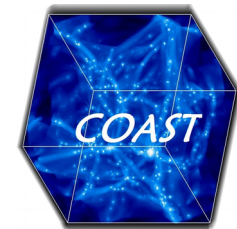
DE LA RECHERCHE À L'INDUSTRIE

cea

Galactica : a new astrophysical simulation open database



Irfu - CEA Saclay
Institut de recherche
sur les lois fondamentales
de l'Univers



CHAPON Damien – damien.chapon@cea.fr

www.cea.fr

<http://irfu.cea.fr/Projets/COAST>

AstroSim - Highlights and prospects for numerical astrophysics in France,
8-11 Octobre, 2018 – ENS Lyon.



Astrophysical simulation database review

Motivation

Existing databases

The “Galactica” database, Terminus & Horus

Introduction

Architecture and Distributed data processing

Editorial management

Preview and web technology integration

On-demand distributed data job requests (Terminus)

Horus : scientific study graphic user interface (GUI)

1. Astrophysical simulation database short review



Astronomy : data reusability is a reality

- Astronomers apply for telescope time.
- They only get the exclusivity on the data for a brief period of time.
- After the public release : more science by other astronomers.





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Reusability of massive simulation data

- Astrophysical simulations produce ever-increasing volume of data.
- Growing cost for society to provide HPC resources (economical context).
- Reusability, a key requirement from :
 - ▶ Funding agencies,
 - ▶ HPC resource allocation committees.
- Main concern : maximize scientific impact (with limited HPC resources).





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Main drags on simulation data mutualization

- Numerical solver and physical model implementation diversity,
- Great diversity of HPC architectures,
- Non-standardization of simulation data formats.





Massive cosmological or turbulence simulation databases

■ Millenium simulation (Virgo consortium)

Virgo - Millennium Database

- ▶ Online SQL query form only.

■ CosmoSim (www.cosmosim.org)

- ▶ Multiple cosmological simulations



- ▶ Use the Daiquiri framework (<https://escience.aip.de/daiquiri>) scientific database publication framework



- ▶ Data access through :

- Online SQL query form (+ plot and export tools).
- SQL scripting (UWS client).

■ CosmoHub : massive cosmological simulation analysis (<https://cosmohub.pic.es>)

■ John Hopkins Turbulence Databases (<http://turbulence.pha.jhu.edu>)





CosmoSim Blog Simulations Documentation Query Contact Login

Query interface

DATABASE STATUS

There are 7 jobs in the queue.
You are using the guest user. For a personal account, please sign up [here](#).

The guest user is using 22.7 MB of its quota of 100.0 MB.

NEW QUERY

SQL query

Mass function query

JOB LIST

- 2016-05-31-14-39-56-8864 ✓
- 2016-05-31-11-35-24-5487 ✓
- 2016-05-25-23-36-59-4230 ✓
- 2016-05-25-22-04-36-8867 ✓
- 2016-05-25-16-36-48-2364 ✓
- 2016-05-19-21-17-03-0933 ✓
- 2016-05-14-00-10-33-5503 ✓
- 2016-05-13-02-43-03-1405 ✓
- 2016-05-13-02-42-12-3246 ✓
- 2016-05-13-01-07-35-2020 ✓
- 2016-05-13-01-04-54-2983 ✓
- 2016-05-13-01-03-03-1208 ✓
- 2016-05-12-16-01-55-2901 ✓
- 2016-05-12-16-01-36-6279 ✓
- 2016-05-12-16-01-18-9254 ✓
- 2016-05-12-16-00-52-3919 ✓
- 2016-05-12-16-00-20-0779 ✓

New Query

SQL query

Place your SQL statement directly in the text area below and submit your request using the button.

Database browser Function browser **Examples**

EXAMPLES

- Select ten most massive FOF groups at z=0 (snapnum 85)
- Mass function of BDMV halos for MDR1 simulation, redshift 0 (snapnum=85)
- Radial profile of most massive BDMV halo (z=0)
- Mass accretion history of a halo
- Particles of a FOF group at z=1

A double click will replace the content of the query field with the example query.

```

1 SELECT 0.25*(0.5+FLOOR(LOG10(Mvir)/0.25)) AS log_mass, COUNT(*) AS num
2 FROM MDR1.BDMV
3 WHERE snapnum=85
4 GROUP BY FLOOR(LOG10(Mvir)/0.25)
5 ORDER BY log_mass

```

Name of the new table (optional)

Submit new SQL Query Clear input window





CosmoSim [Blog](#) [Simulations](#) [Documentation](#) [Query](#) [Contact](#) [Login](#)

Query interface

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- 2016-05-25-22-04-36-8867 ✓
- 2016-05-25-16-36-48-2364 ✓
- 2016-05-19-21-17-03-0933 ✓
- 2016-05-14-00-10-33-5503 ✓
- 2016-05-13-02-43-03-1405 ✓
- 2016-05-13-02-42-12-3246 ✓
- 2016-05-13-01-07-35-2020 ✓
- 2016-05-13-01-04-54-2983 ✓
- 2016-05-13-01-03-03-1208 ✓
- 2016-05-12-16-01-55-2901 ✓
- 2016-05-12-16-01-36-6279 ✓

[Job Overview](#) **Results Table** [Plot](#) [Download](#)

Search

row_id	log_mass	num
1	10.88	3683
2	11.12	452606
3	11.38	3024674
4	11.62	3828931
5	11.88	2638644
6	12.12	1572685
7	12.38	926764
8	12.62	544650
9	12.88	312360
10	13.12	174164

Page 1 of 2 (19 rows total) Show 10 rows

DATABASE COLUMNS

Name	Type	Unit	UCD
row_id	bigint		hide
log_mass	double(19,2)		hide
num	decimal		hide

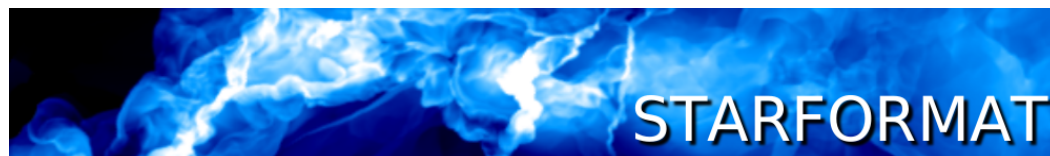
► Statistical approach to data access





StarFormat (Observatoire de Paris-Meudon)

- Molecular cloud formation/evolution/collapse simulation database,
- Online SQL query form
- Data access web API,
- Downloadable content.
- Cloud selection form,
- On-demand post-processing services.



Extract a subset of clump data from the simulation

What kind of values do you want to extract?

a projection of column density
 a cube of density
 a cube of pressure
 a cube of velocity
 a cube of magnetic field

Extraction box size: pc
(50,00 pc for the whole simulation, the number of cells along each axis is $2^{L_{max}}$)

Centered on: X (pc) Y (pc) Z (pc)

Precision L_{max} : corresponding to a resolution of 0.048 pc/cell
(maximum L_{max} allowed for this size of extraction: 10)

E-mail address (to receive a link to download the results):

Results fileformat: ASCII BIN FITS HDF5

If you need access to bigger sets of data, please e-mail the PI of the project.

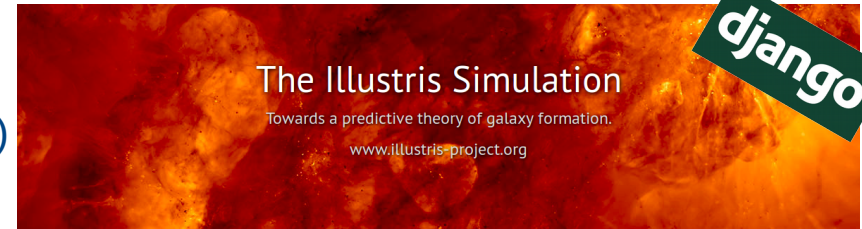
Data freely accessible and reusable under the Open Database Licence. [OPEN DATA](#)





The Illustris project (www.illustris-project.org)

- Data access REST API (Python/Matlab/IDL scripting)
- Downloadable media + raw data access
- Dark matter halo catalog search form.



Public Data Access [Overview](#) / [Subhalo Search](#)

You can search on min/max ranges for one or more Subhalo fields. When you select a field, the minimum, mean, and maximum at this snapshot are calculated for reference. The icons on each row link to: full details in the browsable API (spyglass), merger tree visualization (tree), galaxy stellar images (picture), snapshot extraction (download arrow).

1. Select simulation: and snapshot: or enter snapshot number:

2. Select search fields and enter bounds:

Field	>=	<=	min	mean	max
<input type="text" value="mass"/>	<input type="text" value="10.0"/>	<input type="text" value="20.0"/>	0.131521	10.5845	25250.1

+ Add Search Field

Search

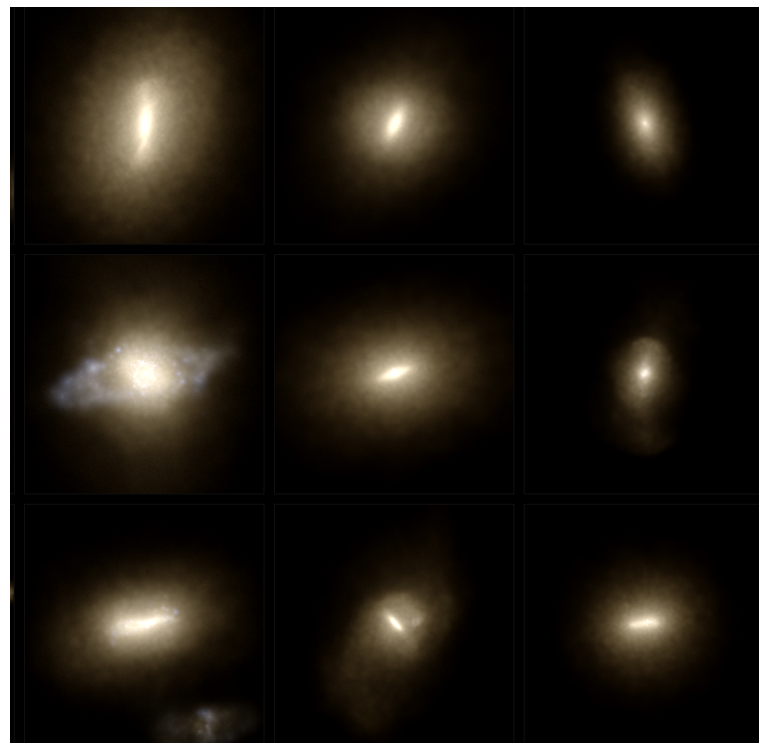
ID	M_{tot}	M_{tot}	M_*	M_{gas}	M_{DM}	x	y	z	$r_{1/2}$	SFR	$Z_*(2r_{1/2,*})$	$Z_{\text{gas}}(2r_{1/2,*})$	v_{max}	σ_v	m_V	m_B	m_R
	[$10^{10} M_{\odot}/h$]	[$\log M_{\odot}$]	[$10^{10} M_{\odot}/h$]	[$10^{10} M_{\odot}/h$]	[$10^{10} M_{\odot}/h$]	[ckpc/h]	[ckpc/h]	[ckpc/h]	[ckpc/h]	[M_{\odot}/yr]	-	-	[km/s]	[km/s]	[mag]	[mag]	[mag]
0	25300.0	14.55	162.0	3070.0	22000.0	900.4	26286.7	18321.9	675.6	4.1110	0.0224	0.00635	896.9	543.8	-23.67	-24.06	-25.26
1	2470.0	13.54	33.0	40.3	2390.0	181.1	24638.8	16896.9	336.5	1.8752	0.0273	0.0601	399.3	262.1	-22.04	-22.45	-23.64
2	406.0	12.76	18.8	0.771	386.0	826.9	26747.3	17363.4	57.2	0.3440	0.0194	0.027	393.6	243.4	-21.08	-21.53	-22.77





The Illustris project (www.illustris-project.org)

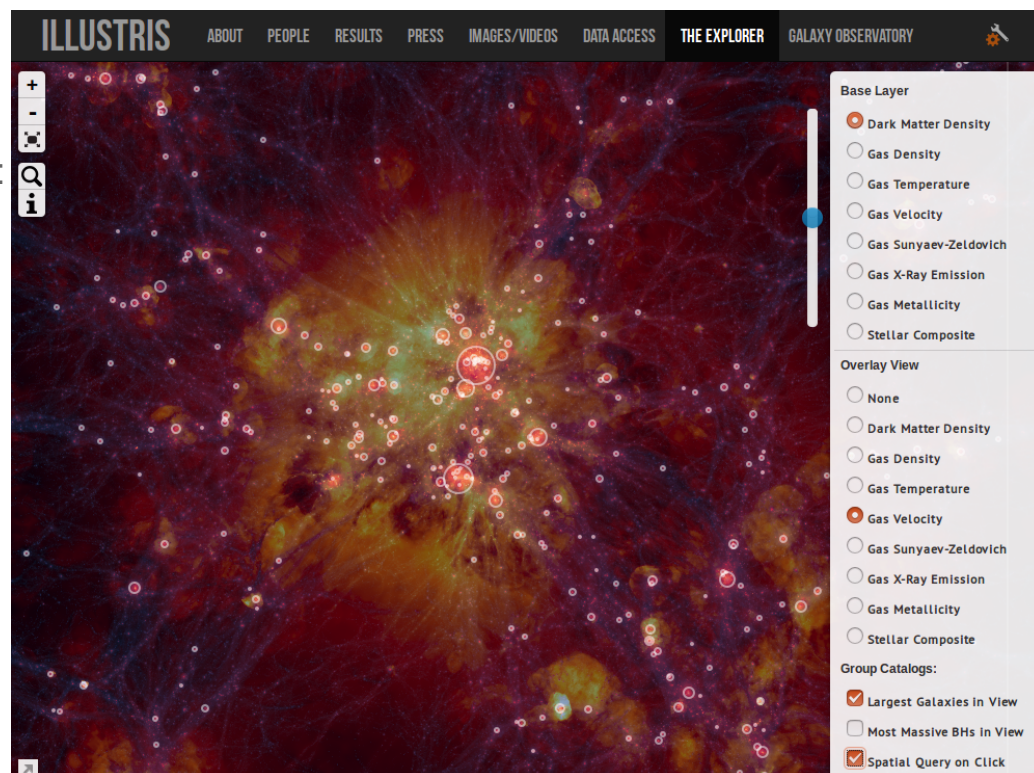
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- Galaxy synthetic observation catalog.
 - ▶ Stellar mock images.





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- Galaxy synthetic observation catalog.
 - ▶ Stellar mock images.
- Simulation explorer and visualisation tools :
 - ▶ Halo merger tree.
 - ▶ Particle extraction form.
 - ▶ Multi-layer 2D maps





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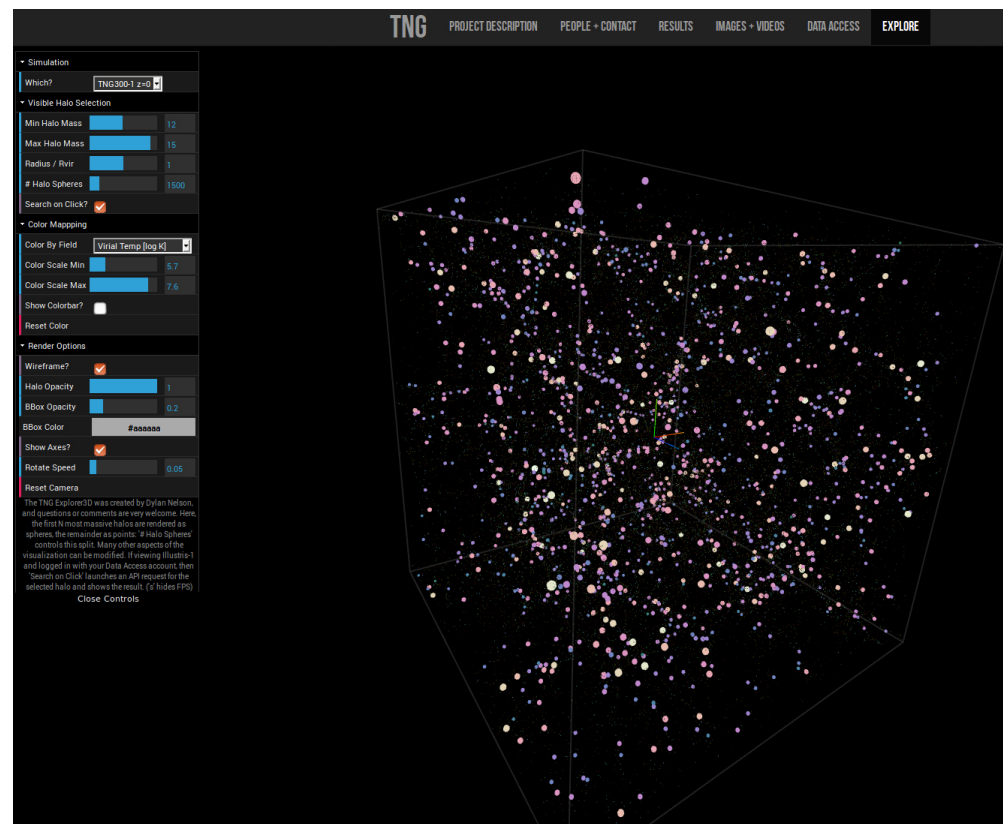
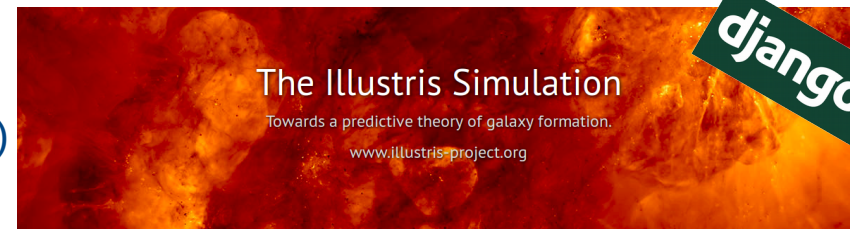
- Multi-layer 2D maps

- 3D simulation explorer (Illustris-TNG) with WebGL

- Single cosmological project,

- Static content,

- Statistical approach, restricted to cosmology.

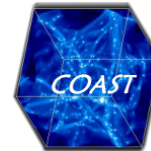




Multi-domain and multi-simulation platform

■ COAST group research fields:

- ▶ Cosmology, galaxy evolution and interactions,
- ▶ Solar MHD, stellar dynamics, supernovæ explosions
- ▶ Accretion disks, ISM, turbulence, star formation,
- ▶ Planet formation, star-planet interactions, planetary atmospheres.

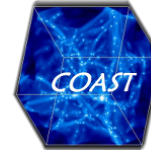




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Share data with scientific collaborators (first, then the rest of the world...)

■ Most information cannot be included in a publication :

- ▶ Complete code configuration (for reproductibility),
- ▶ Dynamical evolution, interactivity with the data (search form, graphic user interface).

■ Share reduced data and provide access to raw data :

- ▶ Pre-processes downloadable content (images, plots, movies, ...),
- ▶ « On-demand » post-processing online tools / job queue management (analysis + visualization)

■ Collaborative work : online pre-publication platform ?



2. The « Galactica » database and « Terminus » data processing servers



Cross-domain multi-numerical project open database

- Generic simulation database (Solar MHD / star-planet interactions / ISM / Supernovæ explosions / Star formation / Galaxy evolution and interactions / Cosmology),
 - Scientific pre-publication collaborative platform,
 - **Open data** free to re-use and redistribute,
 - Web application framework:
- ▶ <http://djangoproject.com>.

django





Cross-domain multi-numerical project open database

Generic simulation database (Solar MHD / star-planet interactions / ISM / Supernovæ explosions / Star formation / Galaxy evolution and interactions / Cosmology),

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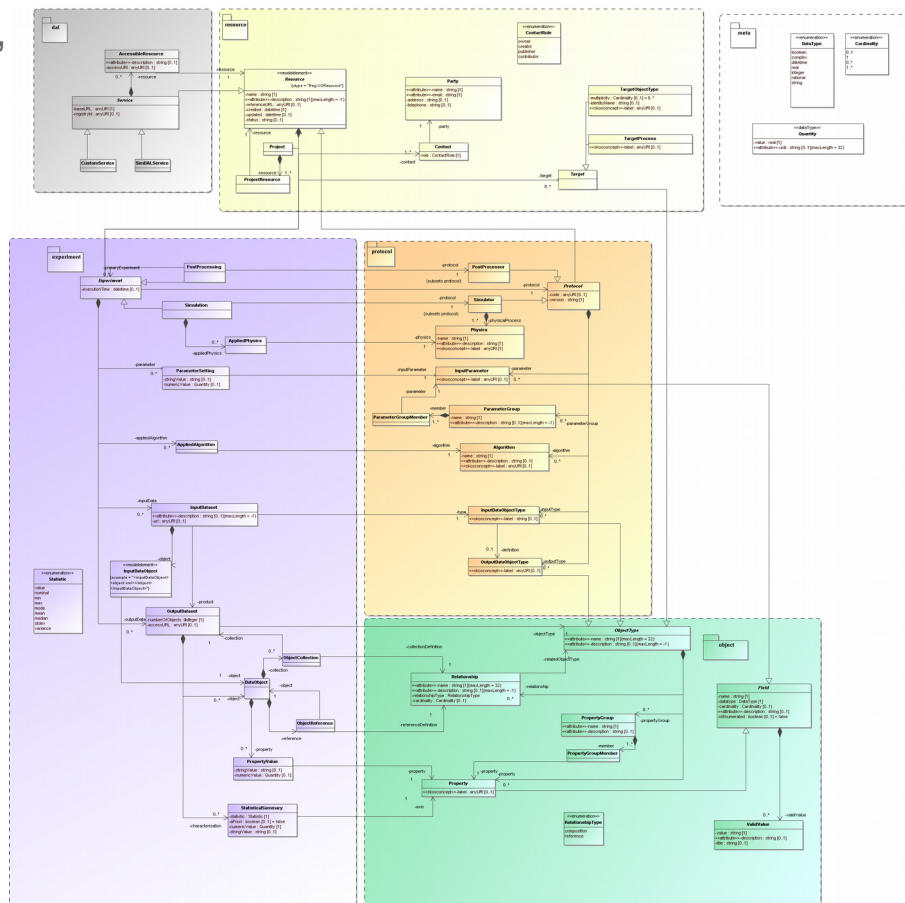


<http://djangoproject.com>.



Based on the **SimDM** IVOA standard :

<https://ivoa.net/documents/SimDM>.





Cross-domain multi-numerical project open database

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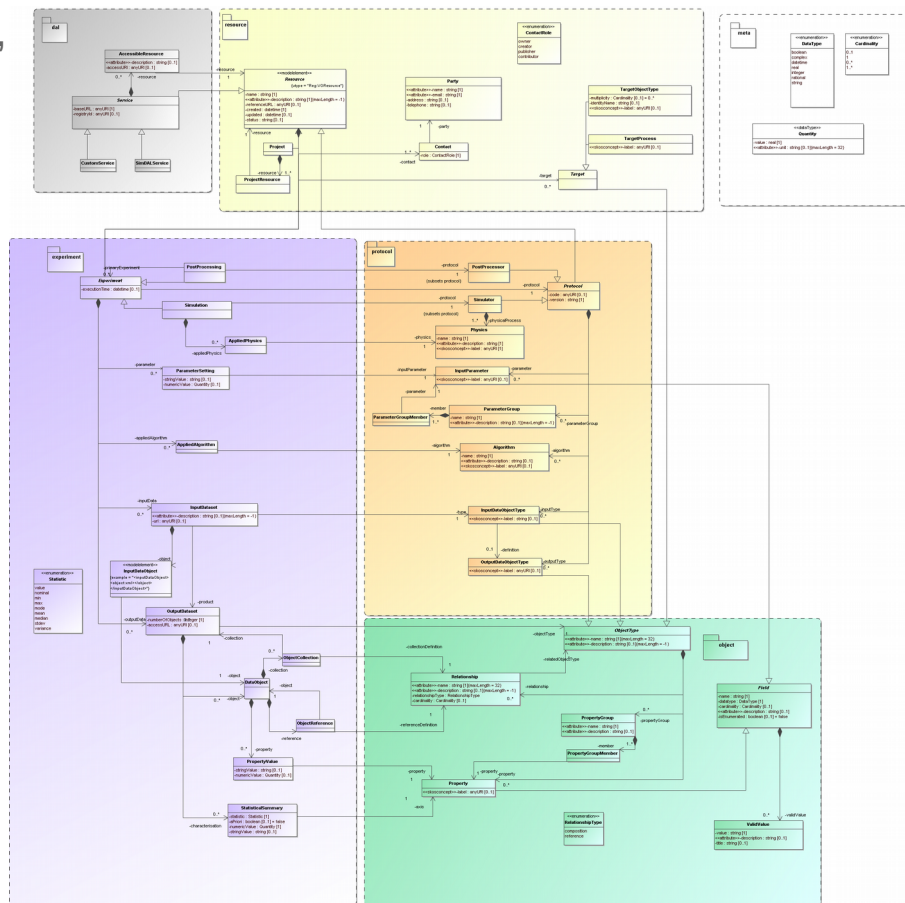
Terminus : async. data processing server

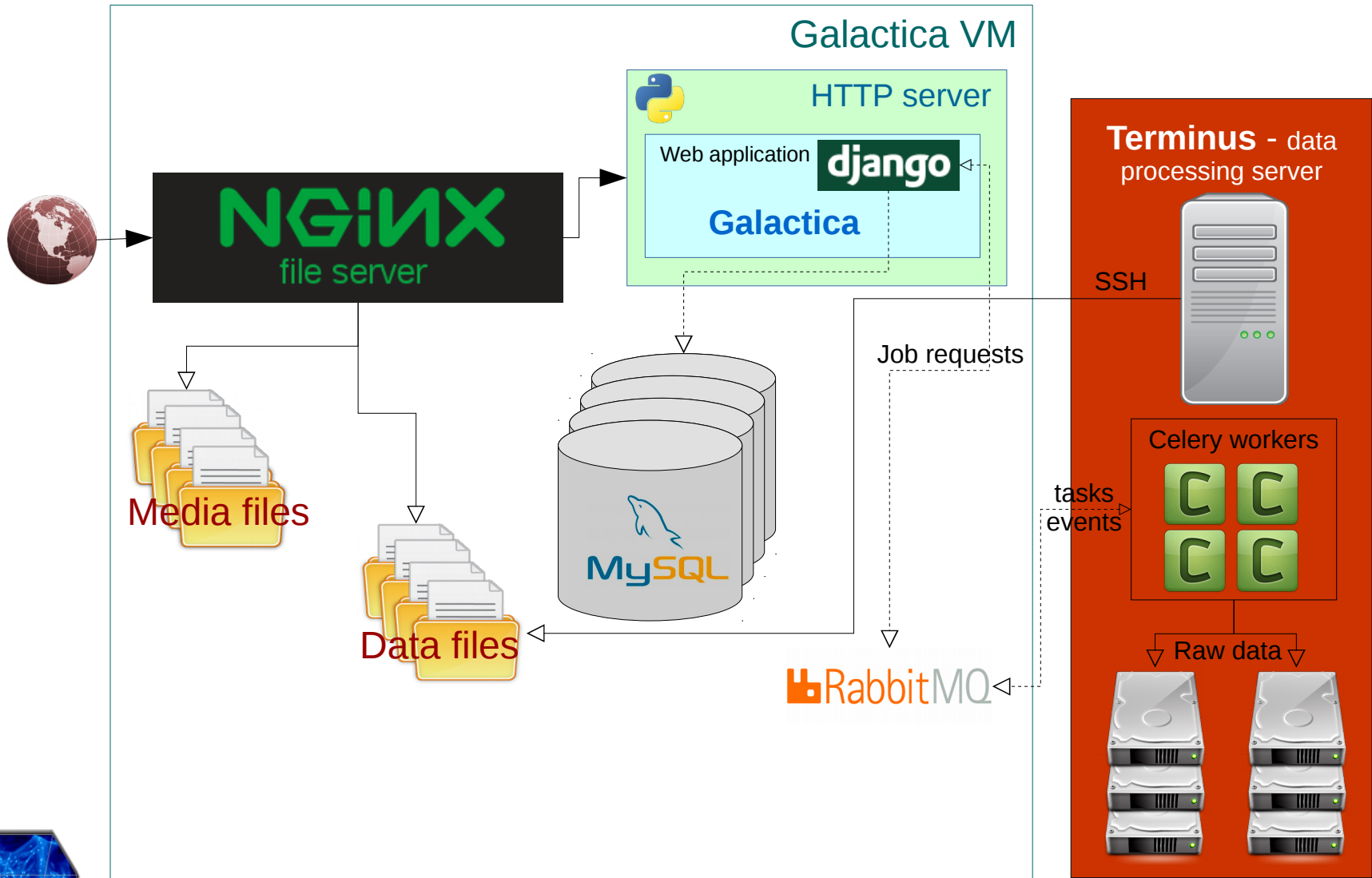
► Celery async. tasks

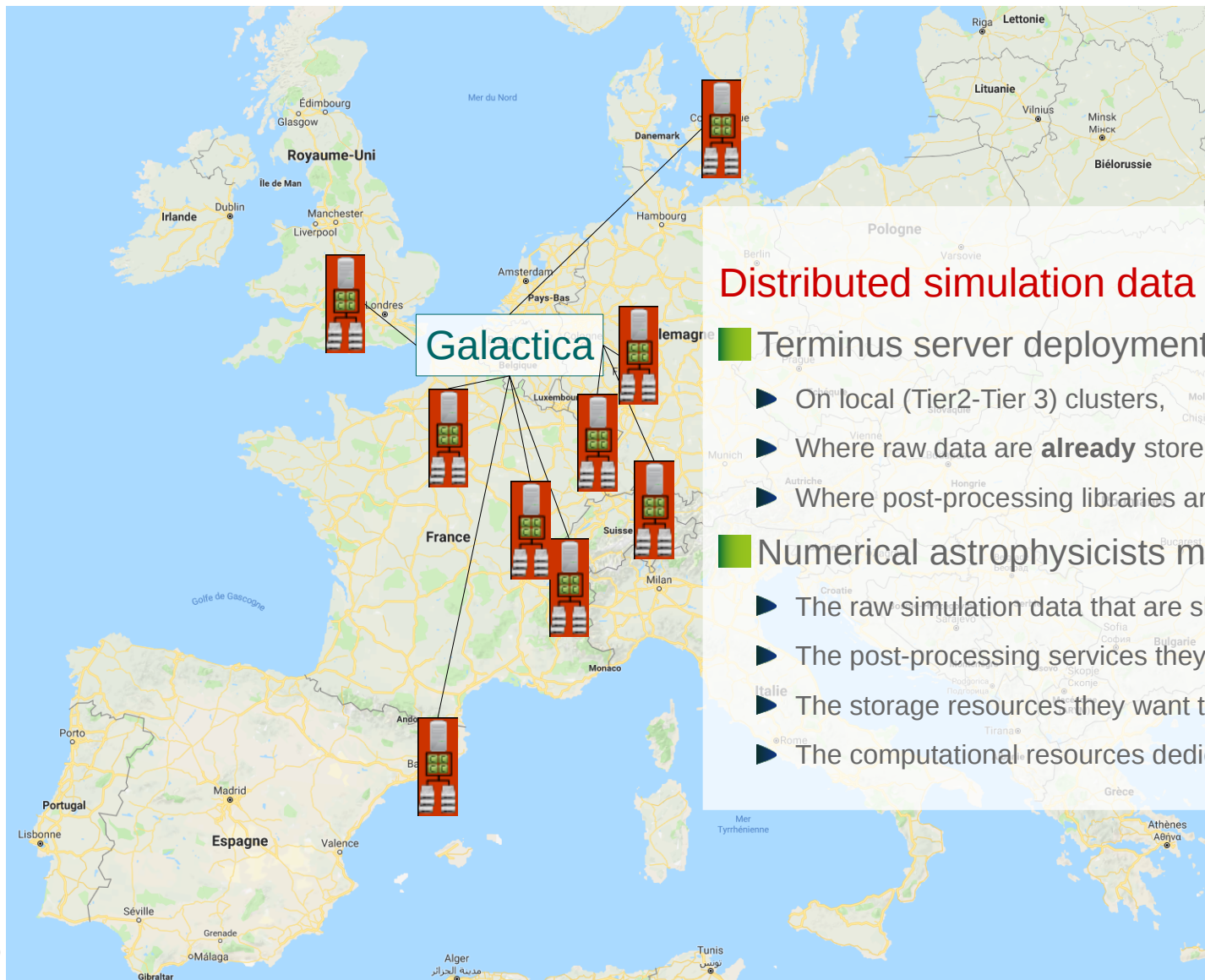


► e.g with a SLURM job queue management

► Comm. : RabbitMQ message broker







Distributed simulation data processing

Terminus server deployment :

- ▶ On local (Tier2-Tier 3) clusters,
- ▶ Where raw data are **already** stored, no transfer needed,
- ▶ Where post-processing libraries are **already** deployed.

Numerical astrophysicists manage

- ▶ The raw simulation data that are shared,
- ▶ The post-processing services they want to provide,
- ▶ The storage resources they want to allocate,
- ▶ The computational resources dedicated to Galactica.





Administration user interface (django-suit)

■ Content management system (CMS) to edit (for authenticated 'editor' users only) :

- ▶ Numerical [Project](#) pages,
- ▶ [Simulation runs](#), associated to [simulation codes](#), and configuration parameters.
- ▶ [Results](#) and their associated [Datafiles](#),
- ▶ [Object catalogs](#) (tabulated data), statistical data and their associated [Datafiles](#).

The screenshot shows the Galactica administration interface. At the top, it says 'Galactica administration' and 'Tuesday, 25. April 2017 15:20'. The user is identified as 'Damien'. The main content area is titled 'Project categories' and contains a table of project categories. A sidebar on the left lists navigation options like 'Home', 'Authorization', 'History', 'Commons', 'Project categories', 'Algorithms', 'Physical processes', 'Input parameters', 'Physical units', 'Projects', and 'Protocols'. A 'COAST' logo is visible in the bottom left corner of the screenshot.

<input type="checkbox"/>	Category label	Alias	Projects	Administrator	Since version	Order	▼ ×
<input type="checkbox"/>	Solar Magnetohydrodynamics	MHD_SOL	1 🔍	Allan Sacha BRUN	1.0.0	↑ ↓	
<input type="checkbox"/>	Star-planet interactions	INT_STAR_PL	0	Allan Sacha BRUN	1.0.0	↑ ↓	
<input type="checkbox"/>	Star formation	STAR_FORM	1 🔍	Patrick HENNEBELLE	1.0.0	↑ ↓	
<input type="checkbox"/>	Galaxy formation	GAL_FORM	0	Frédéric BOURNAUD	1.0.0	↑ ↓	
<input type="checkbox"/>	Galactic mergers	GAL_MERGERS	1 🔍	Frédéric BOURNAUD	1.0.0	↑ ↓	

1 - 5 / 5 project categories



Administration user interface (django-suit)

Project page edition

Galactica administration
Welcome, Damien. [Change password](#) | [Log out](#)

Home » Galactica » Projects » Colliding flow simulations

- Home
- Authorization
- History
- Commons
- Projects
- Project list
 - [Add new project](#)
- Protocols
- Experiments
- Results
- Target objects
- Products
- Statistical data
- On-demand services

General
Contacts

Project information

Project category: *	Star formation
Alias:	COLL_FLOW <small>Define a unique project key here.</small>
Creator: *	Patrick HENNEBELLE
Name: *	Colliding flow simulations
Reference URL:	http://
Short description: *	This project aims at describing self-coi <small>Short description displayed in project list table only.</small>

Summary

This project aims at describing self-consistently the formation of molecular clouds starting from the very diffuse atomic interstellar medium.

A flow of warm neutral medium (of densities of the order of 1 cm^{-3}) is arbitrary imposed (either as boundary or as initial conditions). Under the influence, first of cooling and ram pressure and then later of gravity, the gas undergoes a series of contraction reaching quickly a densities in the range of 10^{2} cm^{-3} to 10^{4} cm^{-3} . Then, in a second step gravity takes over and triggers the formation of dense cores which collapse and form stars.

The aim of these runs is to study the formation of molecular clouds from the warm atomic neutral medium (related reference [Hennebelle et al. L43 A&A 486, 2008](#)). Starting the simulation with WNM only, a converging flow is imposed from the left and from the right. The converging flow has a velocity equal to few times the sound speed of the WNM on top of which fluctuations have been superimposed. The magnetic field is initially uniform. The simulations includes atomic cooling and gravity. After a few million years, dense gas develops and eventually collapses.

Save

Save and continue editing

Save and add another

[Delete](#)

Tools

- [History](#)
- [View on site](#)
- [Add project](#)





Administration user interface (django-suit)

Project page edition – user permissions (read/write)

Galactica administration Tuesday, 9. October 2018 21:15 Welcome, Damien. Change password | Log out

Home » Galactica » Projects » Self-regulated interstellar medium and intermediate galactic scales

Administrators Select users with administration permissions for the protocols/experiments included in this project. Administrators WILL NOT have addition/deletion/edition permissions over th

Administrators:

Available administrators

Filter

Sébastien FROMANG
Sam GEEN
Matthias GONZÁLEZ
Patrick HENNEBELLE

Chosen administrators

Allan Sacha BRUN

[Remove all](#)

[Choose all](#)

Hold down "Control", or "Command" on a Mac, to select more than one.

Contributors Select project contributors (NO administration permissions). Contributors will be granted 'private view' access for this project.

Contributors:

Available contributors

Filter

Frédéric BOURNAUD
Allan Sacha BRUN
Sébastien FROMANG
Matthias GONZÁLEZ

Chosen contributors

Sam GEEN
Olivier IFFRIG
Juan-Diego SOLER-PULIDO

[Remove all](#)

[Choose all](#)

Hold down "Control", or "Command" on a Mac, to select more than one.

Save

Save and continue editing

Save and add another

[Delete](#)

Tools

- History
- View on site
- Add project

Protocols

- Insert a simulator
- Insert a post-processor

Experiments

- Insert a simulation
- Insert a post-processing run

Target objects

- Insert a target object





Administration user interface (django-suit)

Protocol page edition

Galactica administration
Welcome, Damien. [Change password](#) | [Log out](#)

Home

Authorization

History

Commons

Projects

Protocols

Simulators

Post-processors

Experiments

Results

Target objects

Products

Statistical data

Terminus

Home » Galactica » Simulators » RAMSES-MHD

General
Input parameters
Physics and algorithms

Simulator information

Alias:	RAMSES_MHD <small>Define a unique protocol key here.</small>		
Creator: *	<input type="text" value="Patrick HENNEBELLE"/>		
Project:	Self-regulated interstellar medium and intermediate galactic scales		
Name: *	<input type="text" value="RAMSES-MHD"/>	Reference URL:	<input type="text" value="http://http://www.ics.uzh.ch/~teyssier/ramses"/>

Protocol

Code: *	<input type="text" value="RAMSES"/>	Version: *	<input type="text" value="3.0.0"/>
---------	-------------------------------------	------------	------------------------------------

Summary

RAMSES was developed in Saclay to study large scale structure and galaxy formation. It is now a rather flexible package to be used for general purpose simulations in self-gravitating fluid dynamics.

It is written in [Fortran 90](#) with extensive use of the MPI library. It is a free software for non-commercial use only.

This code is a grid-based hydro solver with adaptive mesh refinement. As opposed to *patch-based AMR*, cells are refined on a cell by cell basis: is therefore called a **tree-based AMR**.

A very simple interface based on *Fortran namelist* can be used to specify runtime parameters.

A few routines can be modified to set more complex initial or boundary conditions.

Save

Save and continue editing

Save and add another

[Delete](#)

Tools

History

View on site





Administration user interface (django-suit)

■ Simulation list for a given project

Home » Galactica » Simulations

keyword Project: Self-regulated interstell Search 6 results [9 total](#)

« 2013 |

<input type="checkbox"/>	Name	Creator	Project	Snapshots	Creation date	Order
<input type="checkbox"/>	B0-M4-CR10-L10	Damien CHAPON	Self-regulated interstellar medium and intermediate galactic scales	1 <input type="button" value="Add a snapshot"/>	Sept. 26, 2018, 4:08 p.m.	↑ ↓
<input type="checkbox"/>	B1-M4-CR10-L10	Damien CHAPON	Self-regulated interstellar medium and intermediate galactic scales	2 <input type="button" value="Add a snapshot"/>	Sept. 26, 2018, 4:08 p.m.	↑ ↓
<input type="checkbox"/>	Prob 3 (high res.)	Damien CHAPON	Self-regulated interstellar medium and intermediate galactic scales	2 <input type="button" value="Add a snapshot"/>	Sept. 26, 2018, 4:09 p.m.	↑ ↓
<input type="checkbox"/>	Prob 3 hydro (high res.)	Damien CHAPON	Self-regulated interstellar medium and intermediate galactic scales	2 <input type="button" value="Add a snapshot"/>	Sept. 26, 2018, 4:09 p.m.	↑ ↓
<input type="checkbox"/>	Prob 5 (high res.)	Damien CHAPON	Self-regulated interstellar medium and intermediate galactic scales	2 <input type="button" value="Add a snapshot"/>	Sept. 26, 2018, 4:09 p.m.	↑ ↓
<input type="checkbox"/>	Prob 4 (high res.)	Damien CHAPON	Self-regulated interstellar medium and intermediate galactic scales	2 <input type="button" value="Add a snapshot"/>	Sept. 26, 2018, 4:10 p.m.	↑ ↓

----- 0 of 6 selected

1 - 6 / 6 simulations





Data import from « Galactica archive » files

■ Example : project import

► **Horus** exported file upload (*.tar.gz containing JSON metadata + attached datafiles),

The screenshot shows the Galactica administration interface. At the top, there is a dark header with the text 'Galactica administration' on the left, the date and time 'Wednesday, 26. April 2017 13:51' in the center, and 'Welcome, Damien. Change password | Log out' on the right. Below the header is a navigation menu on the left with items: Home, Authorization, History, Commons, Projects (highlighted), Project list, and Add new project. The main content area shows a breadcrumb trail: Home » Galactica » Projects » Import project. A light blue box contains the instruction: 'Please select a compressed archive file (*.tar, *.tar.gz, *.tar.bz2) to upload into the database.' Below this is the 'Project upload form' with two fields: 'Format' with a dropdown menu set to 'TAR archive (*.tar, *.tar.gz, *.tar.bz2)' and 'File to import' with a 'Parcourir...' button and the text 'Aucun fichier sélectionné.' To the right of the form is a blue 'Upload and preview' button.





Data import from « Galactica archive » files

■ Example : project import

- ▶ **Horus** exported file upload (*.tar.gz containing JSON metadata + attached datafiles),
- ▶ Database import report,

The screenshot displays the 'CoastDB administration' web interface. At the top, it shows the date 'Wednesday, 8. June 2016' and the time '01:58'. A navigation breadcrumb trail reads 'Home » Coastdb » Simulations » Import simulation'. A light blue message box states: 'Check the import preview and click 'Confirm import' to save the changes in the database.' Below this is a green 'Import preview' section containing a bulleted list of successful import actions:

- Simulation 'Hydrodynamical simulation (imported)' successfully imported.
 - Snapshot 'Snapshot #20 (t=6.52 Myr)' successfully imported.
 - Snapshot 'Snapshot #22 (t=8.3 Myr)' successfully imported.
 - Product 'Clump catalog' successfully imported.
 - ProductDataFile 'Velocity dispersion map' successfully imported.
 - ProductFile 'irfu.png' successfully imported.
 - ResultDataFile 'Density map' successfully imported.
 - ResultFile 'mw_density_00030.png' successfully imported.
 - ResultDataFile 'Column density map (XY)' successfully imported.
 - ResultFile '00022_col_dens_xy.png' successfully imported.

A green 'Confirm import' button is located at the bottom of the preview section. On the left side of the interface, a sidebar menu includes options like Home, Projects, Protocols, Experiments, Simulations (highlighted), Post-processing runs, Results, Products, and Statistical data.





Data import from « Galactica archive » files

Example : project import

- ▶ **Horus** exported file upload (*.tar.gz containing JSON metadata + attached datafiles),
- ▶ Database import preview,
- ▶ Project full deployment in the Galactica database with a single click.

The screenshot shows the Galactica web interface. At the top, there is a navigation bar with 'Home', 'Topics', and 'About' menus, a search bar for 'project/simulation', and the user name 'Patrick HENNEBELLE'. The main content area is titled 'Snapshots' and displays a list of simulation snapshots. The selected snapshot is 'Snapshot #22 (t=8.3 Myr)'. Below the title, there are several rows of data visualization options, each with a download icon:

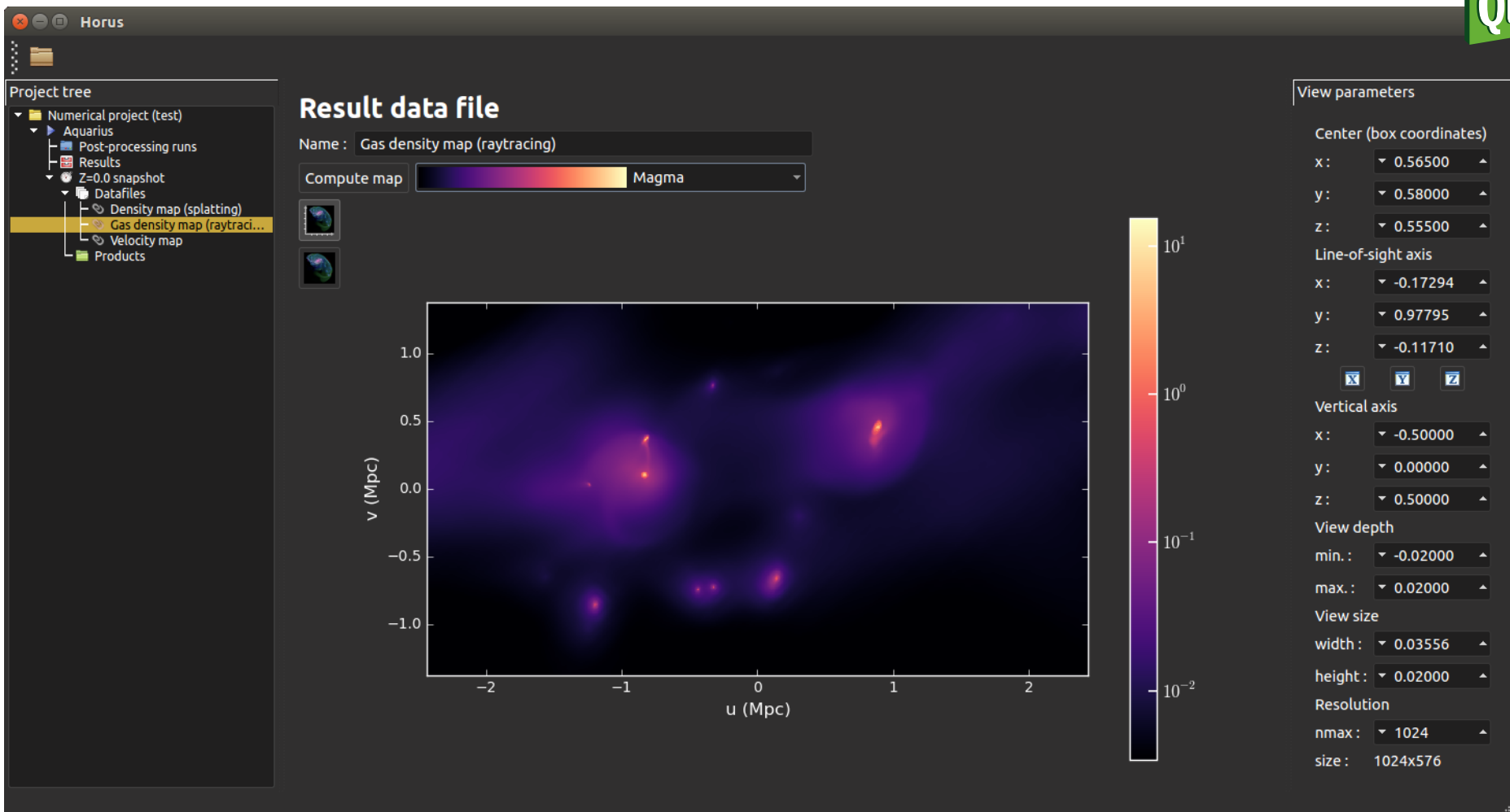
- Density map
- Column density map (XY)
- Column density map (YZ)
- Temperature cut (XY plane)
- Mass vs. density** (highlighted in blue)
- Magnetic intensity vs. density
- Temperature vs. density

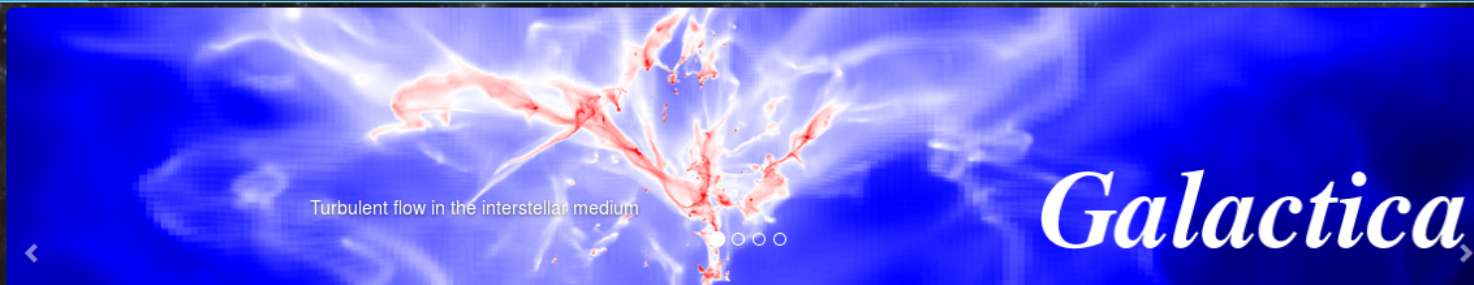
For the 'Mass vs. density' option, there are two download links: 'ASCII' and 'PNG'. Annotations with blue boxes and arrows point to these links:

- A box labeled 'ASCII-formatted file download link' points to the 'ASCII' link.
- A box labeled 'PNG image file download link' points to the 'PNG' link.

On the left side of the interface, there is a sidebar menu with options: Summary, Parameters, Algorithms, Applied physics, and Snapshots. Under 'Snapshots', there are three time points: t=6.52 Myr, t=8.3 Myr (selected), and t=11.25 Myr.







The Galactica simulation database


The **Galactica** database results of heavy numerical simulations computed in various fields of computational astrophysics (solar magnetohydrodynamics, star-planet interactions, star formation, galaxy formation, galaxy mergers). The **Galactica** project gives observers and computational astrophysicists access to the results of these numerical simulations, which could be useful to help prepare or analyze observations or compare with other numerical studies.

The contributors of this database will provide a wide range of reduced data but will also give authenticated users the possibility to run online post-processing requests on the raw simulation data to fulfill one's specific needs.

Solar Magnetohydrodynamics

Project	Description
Solar flare project	This project aims at describing self-consistently the formation of solar flares.

Star formation

Project	Description
Colliding flow simulations	This project aims at describing self-consistently the formation of molecular clouds starting from the very diffuse atomic interstellar medium.
FRIG project (Démo) 	

Galactic mergers

Project	Description
High-resolution NGC4038/39 galaxy merger	This project aims at describing self-consistently the merger of the Antennae(NGC4038/39) galaxies.





FRIG project (D mo)



Summary

> Available simulations

-> Run #6 (Zoom #7)

Summary

This project aims at describing self-consistently the formation of molecular clouds starting from the very diffuse atomic interstellar medium.

A flow of warm neutral medium (of densities of the order of 1 cm^{-3}) is arbitrary imposed (either as boundary or as initial conditions). Under the influence, first of cooling and ram pressure and then later of gravity, the gas undergoes a series of contraction reaching quickly a densities in the range of 10^2 cm^{-3} to 10^4 cm^{-3} . Then, in a second step gravity takes over and triggers the formation of dense cores which collapse and form stars.

The aim of these runs is to study the formation of molecular clouds from the warm atomic neutral medium (related reference [Hennebelle et al. L43 A&A 486, 2008](#)). Starting the simulation with WNM only, a converging flow is imposed from the left and from the right. The converging flow has a velocity equal to few times the sound speed of the WNM on top of which fluctuations have been superimposed. The magnetic field is initially uniform. The simulations includes atomic cooling and gravity. After a few million years, dense gas develops and eventually collapses.

In this project the following items can be found:

- values of the run parameters (e.g. strengths of the incoming flow, magnetic intensity at the boundary);
- statistics of the snapshots (as mass in the box, velocity dispersion) for 5 density thresholds and 5 column density thresholds (all numbers are calculated for the cells above these thresholds);
- various images of each snapshot (as density cut, temperature cut, column density);
- possibility to extract 2-dimensional maps from the snapshots and download the corresponding data;
- the results of clump extraction for various density thresholds, which include the statistics of the clumps (e.g. position, mass), clump images, possibility to extract and download 3-dimensional cubes of data.

The simulations have been performed with the [RAMSES-MHD code](#) ([Teyssier 2002, A&A, 385, 337](#), [Fromang et al., A&A, 457, 371](#)). This is a mesh refinement code, implying that it can increase locally the spatial resolution by adding new cells in the computation. It uses the Godunov method and constraint transport method to maintain the divergence of the magnetic field equal to zero.

Available simulations

[Run #6 \(Zoom #7\)](#)

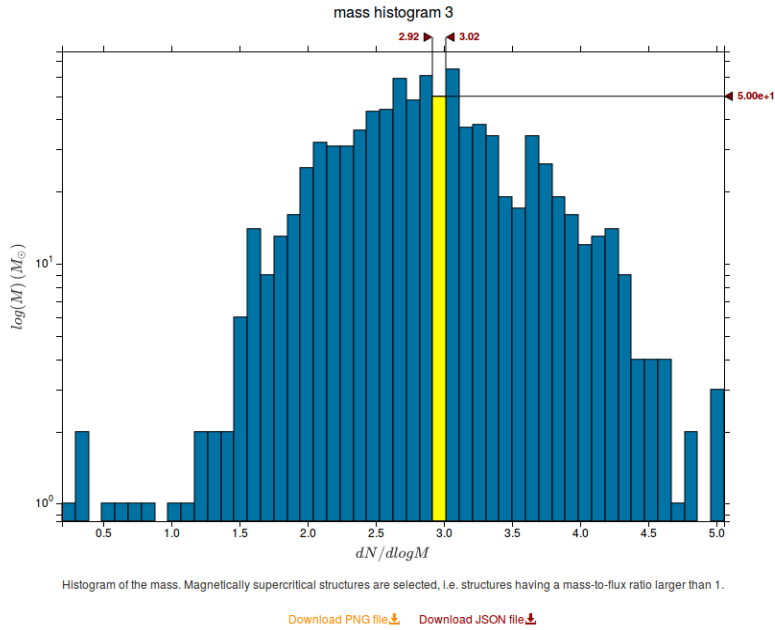
Run #6 (zoom #7)

This run considered as "fiducial" has an effective numerical resolution equal to 1024^3 grid cells implying that the size of the smallest cell is about 0.05 pc. The magnetic field in the run and the velocity of the incoming flow are about $5 \mu\text{G}$ initially (but get amplified in the dense regions) and 18 km.s^{-1} (about twice the sound speed of the warm neutral phase).

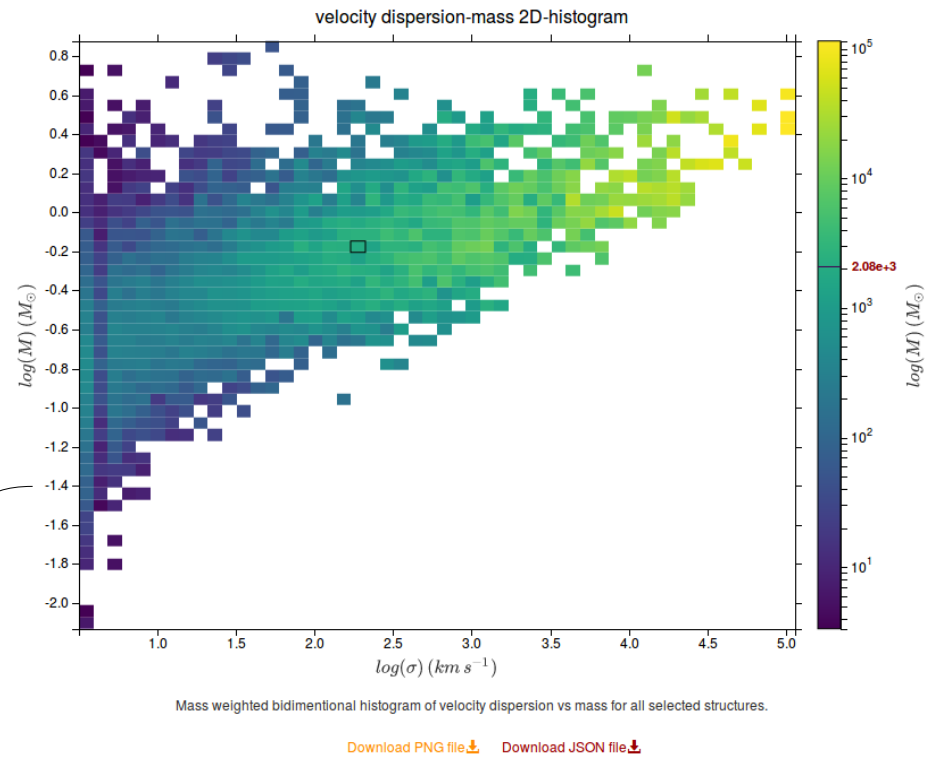




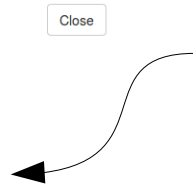
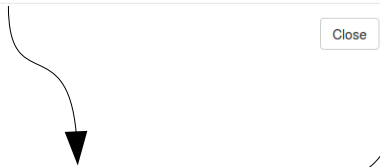
mass histogram 3



velocity dispersion-mass 2D-histogram



D3JS-generated plot
Data-Driven Documents



Close





Hydrodynamical

Summary

Parameters

Algorithms

Applied phy...

Snapshots

Summary

This run is identical to the "fiducial" run except that the magnetic field is not considered. Although this is certainly not fully realistic, this allows to study the difference between the magnetized and non-magnetized runs. The velocity of the incoming flow is about 18 km.s^{-1} and the magnetic field intensity is $5 \mu\text{G}$.

Maxwell + Poisson + conservation equations :

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0}$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = - \frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \epsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$

$$\Delta \Phi = 4\pi G \rho$$

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{v}) = 0$$

$$\frac{\partial(\rho \mathbf{v})}{\partial t} + \nabla \cdot (\rho \mathbf{v} \times \mathbf{v}) + \nabla P = - \rho \nabla \Phi$$

$$\frac{\partial e}{\partial t} + \nabla \cdot ((e + P) \mathbf{v}) = - \rho \mathbf{v} \cdot \nabla \Phi$$





Gas clump catalog

Gas clump catalog (1000 gas clump objects)

Search filters

Set custom search filters to get your own gas clump subset.

Field	Unit	Range	Min.	Mean	Max.	Std dev.
<input type="checkbox"/> x	pc	85.062 <input type="text"/> <input type="range"/> 160.786	85.063	120.139	160.786	9.398
<input type="checkbox"/> y	pc	81.703 <input type="text"/> <input type="range"/> 179.932	81.703	125.221	179.931	21.424
<input type="checkbox"/> z	pc	475.565 <input type="text"/> <input type="range"/> 524.939	475.565	500.138	524.939	10.686
<input checked="" type="checkbox"/> mass	M_{\odot}	154.591 <input type="text"/> <input type="range"/> 312.839	3.478	23.288	415.153	36.755
<input type="checkbox"/> Mach number	year	1.149 <input type="text"/> <input type="range"/> 65.384	1.150	6.787	65.383	6.722

Show results. Sort by in order.

Matching gas clump objects (from #1 to #10) total: 15 1 2 [Next >](#)

Id	data	x (pc)	y (pc)	z (pc)	Vx (km·s ⁻¹)	Vy (km·s ⁻¹)	Vz (km·s ⁻¹)	Bx (μG)	By (μG)	Bz (μG)	mass (M_{\odot})	Mach number (year)	Mean density (cm ⁻³)	
433		121.261636	91.849396	522.946765	7.348302	6.269845	-8.942960	-34.846606	-30.228226	-20.284440	306.296834	20.364663	819084.130884	
698		121.016476	91.956830	521.328851	3.388084	2.483125	-12.323844	-142.875361	-81.904641	-38.387619	295.037627	28.461312	925304.088369	
197		121.301052	133.770963	502.400027	4.172585	4.522596	-7.689792	-4.861375	-43.687804	-206.818369	264.277486	15.789045	2964930.201531	
340		100.232015	90.004712	512.007509	3.002069	4.098	-1.515494	-14.978375	56.230397	-92.292502	-30.423011	256.753235	31.519099	2631802.744069
125		100.232015	90.004712	512.007509	3.002069	7866	7.887752	12.689819	616.651696	153.904790	409.624362	256.516219	21.366143	2224983.286133
201		100.232015	90.004712	512.007509	3.002069	0.235002	-2.657135	229.561244	-25.651715	-175.915842	249.030341	12.549808	550245.956674	
741		118.904722	124.810584	487.115812	2.172452	4.867065	1.954081	19.152011	26.586855	21.156760	222.690546	22.104092	5594642.961254	

Ray-traced mass-weighted gas density map





Data post-processing form

■ Frontend (e.g. gas density map), for authenticated users only.

job request 🔒

Gas clump catalog : item 197

Ray-traced mass-weighted gas density map

Ray-traced mass-weighted density map of the gascontent displayed in log scale (values are computed in cm^{-3} unit). The map can be projected either along the x, y or z axis of the simulation box.

center (x-axis)*	<input type="text" value="0.121301"/>	▲ ▼	map center coordinate along x axis
center (y-axis)*	<input type="text" value="0.133771"/>	▲ ▼	map center coordinate along y axis
center (z-axis)*	<input type="text" value="0.5024"/>	▲ ▼	map center coordinate along z axis
map size*	<input type="text" value="0.1"/>	▲ ▼	map size in (box unit)
Projection axis*	<input type="button" value="z ▼"/>		ray-traced map projection axis


^ Go to top OPEN DATA








User job requests

Raw data post-processing (backend)

- ▶ Job request sent to the Terminus server instance hosting the data.
- ▶ Async. notifications via a RabbitMQ messaging server.  RabbitMQ

Damien CHAPON (Admin) ▾

-  User profile
-  My job requests
-  Log out

My job requests

Job requests :

Job request #7 [2017-04-26 18:12:51]
Submitted

Job request #6 [2017-04-26 18:09:13]
Submitted

Service title Ray-traced mass-weighted gas density map

Job creation date 2017-04-26 18:08:59


Target		Parameters	
Category	Star formation	center (x-axis)	0.1213
Project	FRIG project (Démo)	center (y-axis)	0.1337
Experiment	Run #6 (Zoom #7)	center (z-axis)	0.5024
Product	Gas clump catalog (Snapshot #249)	map size	0.15
Object	Gas clump #197	Projection axis	y








User job requests

Raw data post-processing (backend)

- ▶ Job request sent to the Terminus server instance hosting the data.
- ▶ Async. notifications via a RabbitMQ messaging server.  RabbitMQ

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My job requests

Job requests :

Job request #4 [2017-06-23 16:56:50] Pending execution

Service title Ray-traced mass-weighted gas density map

Job creation date 2017-06-23 16:56:50


Target		Parameters	
Category	Star formation	center (x-axis)	0.573041
Project	Large scale simulation project	center (y-axis)	0.849783
Experiment	Probe 3 (high-res)	center (z-axis)	0.518265
Product	Gas clump catalog (Snapshot #86)	map size	0.15
Object	Gas clump #2019	Projection axis	y








User job requests

Raw data post-processing (backend)

- ▶ Job request sent to the Terminus server instance hosting the data.
- ▶ Async. notifications via a RabbitMQ messaging server.  RabbitMQ

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My job requests


Job requests :

Job request #4 [2017-06-23 16:56:50]
Published

Service title Ray-traced mass-weighted gas density map

Job creation date 2017-06-23 16:56:50

Target		Parameters	
Category	Star formation	center (x-axis)	0.573041
Project	Large scale simulation project	center (y-axis)	0.849783
Experiment	Probe 3 (high-res)	center (z-axis)	0.518265
Product	Gas clump catalog (Snapshot #86)	map size	0.15
Object	Gas clump #2019	Projection axis	y

Download data 

Email notification





New astrophysical simulation database : Galactica

Integration of building block technologies :



Data-Driven Documents



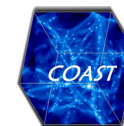
MySQL

Where ?

- ▶ <http://www.galactica-simulations.eu>

For whom ?

- ▶ **Editors** : COAST group members and associated collaborators, and more...
- ▶ **Data access**: Astronomers, numerical scientists, even general public.



When ?

- ▶ Publication : in prep. (2019)

What kind of data/processing library ?

- ▶ Unlimited type of post-processed data : 2D maps, plots, catalog subset, spectra, 3D extracted datacube, etc.
- ▶ Plug-in system : interfaces nicely with any data post-processing library, for any simulation data format.

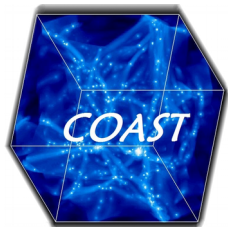




A software suite designed and developed by the COAST group for astrophysicists

- **Galactica** : cross-domain multi-project collaborative platform to publish and share astrophysical simulations : <http://www.galactica-simulations.eu>,
- **Terminus** : distributed data processing across Europe as Galactica services
- **Horus** : post-processing GUI to feed the database,
- Publication : 2019,
- Share your data !
- Ongoing and future work
 - ▶ Online interactive data selection/visualisation component (D3JS, leaflets.js, ...),
 - ▶ Plugin implementations (Terminus services),
 - ▶ Horus GUI import functionalities
 - ▶ Make available several numerical projects in star formation and cosmology.





Thank you for your
attention...

Questions ?

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